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Environment and Development Economics 9: 695–719 © 2004 Cambridge University Press
DOI: 10.1017/S1355770X04001482 Printed in the United Kingdom

Inducing the adoption of conservation technologies: lessons from the Ecuadorian Andes

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ABSTRACT. Programs that provide incentives to induce conservation are often ineffective, leading farmers to abandon conservation once assistance is withdrawn. An alternative to incentives is to offer conservation technologies in conjunction with measures that enhance the short-term profitability of agriculture. Our results indicate that CARE, an international non-governmental organization, has used this approach successfully to promote resource conservation in the Ecuadorian Andes. In particular, the adoption of terraces was found to increase significantly when accompanied by alterations to the agricultural system, such as new crops, biological barriers, and improved agricultural production.

1. Resource conservation programs and developing countries

Recent evidence suggests that more than 40 per cent of the world's agricultural land is moderately to extremely degraded and that this degradation has reduced crop productivity by 13 per cent (Wood *et al.*, 2001). Policy makers have reason to be concerned. The reduction in farm productivity associated with degradation can affect: (1) *aggregate supply or price of agricultural output* if degrading soils are a significant source of agricultural output; (2) *agricultural income or economic growth* if degradation leads to lower production and reduced income; (3) *consumption by poor farm households* if degrading soils are a critical source of food security for subsistence producers; and (4) *national wealth* if degradation reduces productive capacity (Scherr, 1999). Furthermore, the off-site effects of degradation on developing economies can be substantial, possibly exceeding the on-site effects, and are especially costly for hydroelectric projects (Southgate and Macke, 1989). For example, the National Electrical Authority in Ecuador considers erosion from current or abandoned agricultural lands as the principal source of sedimentation in the hydroelectric reservoirs, which supply nearly 70 per cent of the electrical power supply in a country that experiences chronic shortages (INECEL, 1992).

Concerns over the effects of degradation have increased interest among policy makers in promoting conservation measures. A primary objective of these conservation programs is to induce farmers to manage their parcels in a manner that limits the off-farm effects of degradation and that enhances the long-term productivity of agricultural land. Advocates of conservation programs argue that without external intervention farmers will not invest in conservation or, at least, an insufficient number of farmers will invest at an optimal level. The basis of this argument is that the benefits of conservation do not accrue solely, or even primarily, to farmers (net social benefits exceed net private benefits) and to reach a desirable social outcome it is necessary to provide incentives for conservation activities. Further rationales for external intervention include failures in the credit market and the market for information. Since farm-level conservation measures often require high immediate costs with the promise of long-term benefits, the presence of credit market imperfections and failure (particularly for long-term credit) in rural areas of developing economies makes conservation difficult to undertake. In this context, failure to adopt conservation measures does not mean farmers do not perceive benefits to conservation, but are credit constrained and cannot invest. Alternatively, because degradation is a long-term problem and in some circumstances difficult to assess given the number of factors that contribute to the variability of agricultural output, it may be the case that farmers simply do not know that degradation is occurring. Even if farmers have adequate information on degradation, they may have limited information on potential responses to the problem. The lack of conservation may then be a result of poor information.

If farmers' failure to adopt conservation measures is related to limited information, interventions may focus on the provision of information on degradation and on conservation measures. However, if there is a divergence between the social and private optimal level of conservation because of off-farm effects or if credit constraints limit adoption, some form of assistance may be required to induce conservation. Assistance may include credit provision for investing in conservation measures, and various forms of subsidies, such as free inputs, payment for labor used for conservation, or even direct construction of conservation structures. The logic of these programs is that by reducing the short-term costs of conservation, farmers will be induced to conserve for long-term and off-site benefits.

The problem with programs offering incentives is that the conservation measures they promote are often not maintained. For example, in her analysis of adoption and maintenance of the Plan Sierra conservation program in the Dominican Republic, de la Briere (1996) notes that of the 190 program participants surveyed, 91 per cent adopted some conservation practices while in the program. At the time of the survey, however, 27 per cent of adopters had completely abandoned the conservation practices. De la Briere shows that the termination of program subsidies led to an immediate increase in abandonment of conservation practices. Some farmers therefore participate only to receive subsidies. In another study of the Dominican Republic, Carrasco and Witter (1991) report a 90 per cent adoption rate of conservation practices in the MARENA program while subsidies were still being offered. Five years after subsidies had ended, only 53 per cent of adopting farmers still maintained the practices. Obando and Montalván (1994) note a similar phenomenon in the Lake Xolotlan region of Nicaragua. In that region, conservation measures were constructed at no cost to the farmers in order to limit flooding in Managua. Many of the structures were abandoned or destroyed because they interfered with common agricultural practices.

Discerning the causes of the abandonment of conservation measures requires understanding farmers' decision making with respect to the adoption of conservation technologies. As noted, it is often assumed that the adoption of conservation measures does not occur because of high short-term costs and distant future benefits. The abandonment of established conservation measures suggests that this is not the only reason for farmers' reluctance to adopt. Abandonment may be motivated by the fact that maintenance costs of structures exceed the private benefits of conservation. Another more likely reason, noted in the Nicaragua case above, is that conservation interferes with current agricultural practices and lowers short-term agricultural output and profit. For example, terraces lower the surface area available for planting, and often make tractor and oxen use more difficult. This corresponds to the conclusions drawn by Lipper (2001) that natural capital and manufactured capital are often complements and changes in natural capital result in the decline of the effectiveness of manufactured capital inputs. This is particularly a problem when an outside expert, rather than the farmer, determines the location of terraces. Government or NGO officials may erect terraces where they will best conserve soil and water, but not where they are most conducive to agricultural production.

Conservation decisions thus become not solely a matter of comparing the costs of conservation measures and the distant benefits of reduced degradation on productivity, but include the effects on current agricultural production. Murray (1994) notes the interaction between conservation and current production when he writes:

> Enthusiasm for soil conservation is high only when the increments in productivity likely to come from new land use practices rise above a certain threshold. Soil conservation by itself rarely creates or sustains such threshold level of increments. Rather, soil conservation is generally adopted in conjunction with, and response to, other technological or economic shifts . . . Farmers are more open to soil conservation measures when these measures are not presented as the principal element in the project, but rather as secondary, ancillary items in a menu featuring innovations with impressive short-term, income generating potential.

Along similar lines, Barbier (1990) in his study of soil conservation in Java notes that switching from a corn or cassava production system to higher valued crops increased the returns to terracing and thus increased adoption of terraces.

These insights have important implications for the design of conservation programs. Instead of providing subsidies or other incentives to induce adoption of conservation measures, programs should be designed to enhance the short-term profitability of agriculture in a manner that complements conservation. To evaluate whether this hypothesis holds true, in this paper we evaluate a resource conservation program, PROMUSTA,[1] that was implemented by the international non-governmental organization CARE in the Ecuadorian Andes in the late 1980s and into the 1990s. Along with promoting changes in resource management, PROMUSTA encouraged farmers to adopt alternative agricultural activities and alter practices. Incentives were limited to provision of seeds, plants, and inputs and not direct payment for conservation. A menu of options was presented to farmers to increase income generated from agriculture and improve resource management. Plans were developed in conjunction with farmers on a case-by-case basis. The objective of this paper is to evaluate the success of PROMUSTA in inducing adoption of conservation measures. In particular, we want to answer two questions. First, are farmers more likely to adopt conservation measures, such as terraces, if they also alter their agricultural practices? Second, was the PROMUSTA program successful at improving the management of natural resources in the Andes? Data collected from a household survey of 530 PROMUSTA participants and non-participants in 44 communities in the Ecuadorian Andes are used to answer these questions. Towards this end, the remainder of this paper is divided into five sections. Section 2 provides a brief description of CARE's PROMUSTA program. Section 3 discusses the survey design and provides an initial discussion of the data. In section 4, the success of PROMUSTA in inducing terrace adoption on parcels operated by smallholders is evaluated. Section 5 examines how PROMUSTA affected resource management by examining the household-level intensity of adoption of conservation practices. Section 6 provides a brief assessment of the impact of PROMUSTA. Conclusions and policy implications are discussed in section 7.

2. CARE's PROMUSTA Program

PROMUSTA was initiated by CARE International in 1988 in conjunction with the Ecuadorian Ministry of Agriculture and Livestock and state and local government organizations. The formal objective of the project was the promotion of better resource management by smallholders (minifundistas) in the Ecuadorian sierra through the adoption and adaptation of sustainable land use practices with the ultimate objective to improve the quality of life for farmers in the short and long term (PROMUSTA, no date). The farmers targeted by the project were smallholders who were generally producing staple crops for home consumption. The particular staple crop varied by region. For example, corn was the primary staple in Imbabura, barley in Cotopaxi, and potatoes in Chimborazo. In all cases, productivity was low,

[1] PROMUSTA is an acronym for Proyecto Manejo del Uso Sostenible de Tierras Andinas, which translates as Project for the Sustainable Use of Andean Lands.

market access was limited, and, because of the mountainous nature of the Andes, resource degradation was a problem.

Although the project initially focused on promoting soil conservation, as the project progressed and developed it adopted a broader approach that integrated natural resource management with components for strengthening institutions, training and extension, agricultural intensification, crop diversification, pastures and livestock management, forestry and agroforestry, and water management. The menu of technological options developed by PROMUSTA offered diverse possibilities for farmers that were designed to meet local conditions. The mode of operation and the technological options of the PROMUSTA project offer valuable insights to researchers and development professionals interested in that elusive concept of 'scaling up' research results to achieve widespread impact.

While the project planned work in seven mountainous provinces of the Ecuadorian Andes, work began slowly in each region. Therefore, not all communities entered the PROMUSTA program at once and, at the time of the survey, communities were in different phases of the project. Administrative units were organized by region (North, Central, and South) and by area and the initial phase of development in each area (phase 1) included a pre-diagnostic study designed to obtain general information about potential communities in each province. Once possible sites were selected, communities were specifically selected based on the following criteria:

1. interest by both men and women in the project;
2. limited migration (specifically, not greater than 60 per cent);
3. a community economy based on agriculture, forestry, and animal husbandry;
4. a community located in an important watershed;
5. no other similar projects working in the community; and
6. superior community organization.

In total, 193 communities were working with PROMUSTA at the time of the survey.

After the communities were identified in phase 1, a diagnosis of the community and a planning of actions occurred in phase 2. In this phase, PROMUSTA representatives and community members discussed the needs and interests of the community with respect to resource conservation, established the responsibilities and contributions of PROMUSTA and the community participants, and selected farmer-promoters to oversee project activities. The third phase, training and execution, involved executing the plan developed in phase 2 and training the farmers. Training was done through field days, workshops, group discussions, demonstration plots, and trips to farmers' fields in other communities. After initial training and execution of the plan, the community entered a phase of development defined as consolidation and adoption (phase 4). During this stage farmer-promoters and project participants engaged in active participation and movement towards improved management of natural resources, with extensive adoption of new technologies. Finally, once the community reached a level of maturity, and had learned to continue planning and executing conservation without external assistance, the community graduated from the project (phase 5). This decision was made in consultation with community participants. Of course, these phases represent the ideal stages of development for a community. In some circumstances, communities lacked interest in continuing work or failed to progress sufficiently. In those cases, PROMUSTA quit the community. The frequency of community contact with PROMUSTA extension agents varied by phase. Project extension agents received regular training to help them cope with the wide variety of technologies they were supposed to support.

Although the menu of options offered to farmers was community specific, in general, the PROMUSTA program promoted a wide range of technologies from which the farmers, in consultation with extension agents, could choose.[2] The promoted technologies can be grouped broadly into two categories: resource conservation and alterations to the agricultural system. Resource conservation technologies included both slow forming and bench terraces as well as measures to improve water management, such as water runoff channels, reservoirs, bunds, and planting along the contour. Alterations to the agricultural system were more varied and included adoption of new crops (e.g., vegetable plots, fruit trees, horticulture, cultivated pastures), agroforestry, biological barriers along the borders of plots,[3] improved agricultural production through improved varieties, new rotations and better management, and soil quality improvements through composting and worm farming.[4] Based on the technologies promoted within a community, farmers could choose those that best suited the needs of the farm.

3. Survey design and data

The data used in this study were collected by the International Potato Center (CIP), with the active participation of PROMUSTA staff. In selecting communities for the survey, it was deemed important that the sample be stratified in a manner such that the selected communities represented important differences across the PROMUSTA project. The criteria for selecting potential communities were exogenous – i.e., the criteria used were not an outcome of participation such as the level of adoption – and included location within the region, phase in PROMUSTA, distance to urban centers, altitude and soil quality. Based on these criteria, a set of potential communities was identified and the survey communities were randomly chosen from this set. Within each selected community, households were randomly selected to be interviewed for the survey. In total, 530 households in 44 communities were surveyed between June and September 1996.

While the survey included participants and non-participants within each community, it did not include households in communities that did

[2] A detailed description of the PROMUSTA program and the technologies available to farmers can be found in Winters *et al.* (1998).

[3] These included grasses and other plants that could be used to feed animals, such as guinea pigs, which are an important source of food and income in the Andes.

[4] Worm farming refers to the intensive cultivation of earthworms for the purpose of transforming plant and animal waste into humus that is rich in microorganisms. The California red earthworm (*Eisenia foetida*) was used.

not participate in PROMUSTA. This represents a significant weakness in the data since PROMUSTA communities may be different from non-PROMUSTA communities. Two important differences, noted in the community selection criteria in section 2, are the low migration levels and high levels of social capital in the PROMUSTA communities. The results presented in this paper should be viewed with caution since they may only be relevant for communities with 'PROMUSTA-type' characteristics and it would be incorrect to assume that PROMUSTA would have similar effects in communities without these characteristics. However, it is reasonable to assume that communities with these characteristics and that are likely to participate in this type of program would have similar results. The results of the analysis are relevant for communities with limited migration and significant social capital.

The household survey included questions on household demographics, assets, income sources, organizational affiliation, and the adoption of conservation measures and new agricultural practices. Furthermore, as part of the household survey the household management of natural resources was assessed. The enumerator evaluated the resource management practices of every parcel operated by each farmer and determined the land area of that parcel that was managed in an appropriate manner based on CARE's criteria.[5] Criteria included the use of conservation measures, particularly bench or slow-forming terraces, in an appropriate manner. A poorly managed parcel would receive a value at or near zero per cent and a well-managed parcel at or near 100 per cent. Summing over all the land operated by the household, and weighting it by the relative size of each parcel, an intensity of adoption of resource management measures was calculated for each surveyed household.

Recognizing the importance of community factors in adoption of the PROMUSTA package of technologies, a community-level survey was also conducted for each of the 44 communities in which a household survey was conducted. The community-level information was gathered from the extension agents working within the communities and from discussions with key informants in each community.

Table 1 reports information on the 530 sampled households and a comparison of participant and non-participant households. When evaluating this type of program there is the potential for selectivity bias; those who chose to participate in the PROMUSTA program may have been more likely to adopt conservation packages even if the program had not been implemented. The benefits of the program should be measured by the level of adoption that occurred beyond what would have occurred if the program had not been implemented. Of course, we do not know what would have happened if the program had not been implemented, so separating the effects of the program and the self-selection of participants can be difficult. One way to determine selectivity bias is to see if there

[5] Note that these data were not collected by the extension agent working in the community. Instead, it was collected by a PROMUSTA employee who was familiar with CARE's criteria for resource management but not the farmers he or she was evaluating.

Table 1. *Participant versus non-participant households*

		Total	*Participants*	*Non-participants*	*Test*
	Number of observations	530	413	117	
	% of total obs.	100.0%	77.9%	22.1%	
Human capital	Total household members	5.1	5.2	4.6	−2.76***
	Male labor/ha.	8.2	8.3	7.8	−0.26
	Female labor/ha.	8.6	8.8	7.9	−0.44
	Age of household head	42.7	42.9	41.8	−0.74
	Years in agriculture (head)	28.1	27.7	29.5	1.28
	Education level (household ave. years)	3.6	3.6	3.4	−0.73
Income source	Months working off-farm (head)	4.0	3.9	4.6	1.45
	Income from off-farm work (%)	32.4%	30.8%	38.1%	2.31**
Natural capital	Land owned (hectares)	1.0	1.1	0.9	−0.37
	Land operated (hectares)	1.1	1.1	1.0	−0.40
	Number of parcels	1.5	1.5	1.4	−2.39**
	Slope of steepest parcel† (%)	26.8	27.7	23.7	−2.05**
	Altitude of highest parcel (meters)	3,090	3,097	3,013	−0.88
	Distance to furthest parcel (meters)	667	604	887	1.94*
	Fraction of land with non-black soil	0.53	0.55	0.48	−1.45
Physical capital	Value of large animals owned (US$)‡	1,548	1,615	1,309	−1.73*
Social capital	Organization affiliation (no.)	1.3	1.4	0.9	−6.84***
	Was/is director of organization (%)	51.6%	59.7%	23.1%	48.99***
	Indigenous (%)	62.0%	60.9%	65.8%	0.94
Community characterstitics	Years CARE in community	4.7	4.7	4.8	1.48
	Distance to city (population >50,000)	50.2	50.3	49.7	−0.16
	Population density (households/ha)	0.67	0.65	0.73	0.83
	Annual rainfall (cm/year)	63.2	63.2	63.1	−0.06

Notes: Test of difference between non-participant and participant household; t-stats and chi-squared as appropriate.
* significant at 10%, ** significant at 5%, *** significant at 1% level.
† Data on slope are missing for four households.
‡ = Includes cows, horses, mules, pigs, sheep, goats, and llamas. Data are missing for one household.

was any systematic difference between participating and non-participating households. To do this, in table 1 we present tests of difference between participant and non-participant households using t-tests for averages and chi-squared tests for discrete variables and discuss significant differences that emerge between the participant and non-participant households.

The average household size is 5.1 members with members defined as anyone who lived in that household for at least six months of the year. Household labor was defined as including any household member over the age of 14. We distinguished male and female labor, since each is often used for different activities, and we divided labor by operated land area to determine labor availability per unit of land. On average each household had 8.2 male labor units per hectare and 8.6 female labor units per hectare. The higher number of females can be explained by the permanent migration of male labor. Note that households with more members (4.6 versus 5.2) were significantly more likely to participate. This could be due to labor availability but, although participating households tended to have more male and female labor per hectare, this difference is not significant. The age of the head of the household, usually the eldest male, represents the life cycle stage of the household and, along with years in agriculture, represents the experience of the primary decision maker. The average household head is 43 years old and average years in agriculture 28.1. Skill level within the household is measured by average years of education and, on average, household labor has 3.6 years of education.

One-third of household income came from off-farm sources as seen in the percentage of reported off-farm income (32.4 per cent) and the average months per year the head of household works off-farm (4 months). This suggests that for extensive periods of the year, much of household labor is not available for farm work. Not surprisingly, farmers with more off-farm income (38.1 per cent versus 30.8 per cent) tended not to participate in PROMUSTA probably due to time limitations. Farmers on average owned only 1.0 hectare of land and operated slightly more (1.1 hectares) through rental, loan or sharecropping contracts. Seven per cent of farmers surveyed owned no land and 79 per cent owned one hectare or less. Only 5 per cent of farmers owned four or more hectares. Farmers in the sample did not operate many parcels; the average number was 1.5. Sixty-two per cent of farmers worked only one parcel, 27 per cent worked two parcels and the remainder (11 per cent) worked on three to six parcels. The parcels farmers operated can be categorized by slope, altitude, distance from the house, and whether the soil was black or not. There was significant variation in these parcel characteristics with slope varying from 0 to 89 per cent, altitude from 2,000 to 4,500 meters, distance from the house from 0 to 10,000 meters and fraction of non-black soils from 0 to 1. Livestock, particularly large livestock (cows, horses, mules, pigs, sheep, goats, and llamas), can be a source of savings and production for the household. Using prices from a provincial fair in October 1997, we approximated the value of large livestock owned. On average the value of a farmer's livestock is US$1,545, however, nearly half of farmers own less than US$1,000 worth of livestock. Comparing natural and physical capital, participants tended to have slightly more parcels than non-participants (1.5 versus 1.4), steeper parcels (27.7 per cent versus

23.7 per cent), less distant parcels (604 versus 887) and more livestock assets ($1,611 versus $1,309).

Social capital can facilitate information and improve participation. Farmers were members in 1.3 organizations on average and 51.6 per cent of farmers noted they were at one time a director of an organization.[6] Participants were more likely than non-participants to be members of multiple organizations (1.4 versus 0.9) and to have been a director of an organization (59.7 per cent versus 23.1 per cent). This degree of activism was to be expected given PROMUSTA's community selection criteria based on superior community organization. Sixty-two per cent of households report being indigenous. CARE has worked in the surveyed communities for 4.7 years on average with some communities initiating work 11 years prior to the survey and others the year before the surveyed. A plurality of households (25 per cent) started working with CARE three years before the survey. Distance to an urban center of over 50,000 inhabitants varies from 4 to 155 kilometers with the average being 50 km. Access to major markets will also vary with this distance. Population density, defined as the number of households per hectare of land in the community, also varied substantially, from a rather disperse 0.03 households per hectare of land in the community to five households per hectare of land. Only two communities (4.5 per cent) had more than two households per hectare and only eight communities (18.2 per cent) had more than one household per hectare. Average annual rainfall was 63 cm, with the driest community receiving 28 cm/year and the wettest 120 cm/year. Approximately one-third of the communities received 50 cm/year or less of rainfall, one-third between 50 and 75 cm/year, and one-third over 75 cm/year.

While these numbers do indicate some differences between participants and non-participants, a better method of examining participation is the use of a probit regression on participation which estimates the probability of a household participating in the PROMUSTA program given exogenous household characteristics. Table 2 reports these results with the marginal effects (at the sample mean) on participation reported instead of coefficients. Results indicate that the age and agricultural experience of the household head influenced participation in the project. While older farmers tended to be more likely to participate this effect diminished with age. However, years of agricultural experience, controlling for age, is negatively associated with participation. This suggests that, independent of age, farmers with less years of agricultural experience were more likely to participate in the program. While farmers with more land were less likely to participate, farmers with more parcels were more likely to participate with each additional parcel increasing the probability of participation by 5.6 per cent. Not surprisingly, farmers with steeper parcels were more likely to participate in the PROMUSTA program; specifically, for the average farmer, a 10 per cent increase in slope led to a 2.6 per cent increase in the probability of participation. The distance of the household's furthest parcel decreases

[6] The term organization refers to permanent affiliations such as farmers' associations, productions groups, and federations of indigenous people. As a temporary program, PROMUSTA is not considered an organization.

Table 2. *Probit on PROMUSTA participation (Number of households = 525)*

		Marginal effect	*z-stat*
Human capital	Male labor/ha.	0.0007	0.30
	Female labor/ha.	0.0023	1.52
	Age of household head	0.0184	2.50**
	Age of household head squared	−0.0001	−2.08*
	Years in agriculture (head)	−0.0061	−2.60***
	Education level (household ave. years)	−0.0091	−0.98
Income source	Received income from off-farm work†	−0.0531	−1.50
Natural capital	Land owned (hectares)	−0.0080	−1.87*
	Number of parcels	0.0562	1.73*
	Slope of steepest parcel (%)	0.0026	3.06***
	Altitude of highest parcel (meters)	−0.0001	−0.92
	Distance to furthest parcel (meters)	0.0000	−2.21**
	Fraction of land with non-black soil	0.0939	1.79*
Physical capital	Value of large animals owned (US$)	0.0000	1.08
Social capital	Organization affiliation (no.)	0.1753	4.65***
	Was/is director of organization†	0.1845	5.74***
	Indigenous†	−0.1172	−2.89***
Community charactersitics	Years CARE in community	0.0038	0.96
	Distance to city (population >50,000)	0.0012	2.19**
	Population density (households/ha)	−0.0207	−2.41**
	Annual rainfall (cm/year)	−0.0003	−0.35
Provincial dummies‡	Azuay	0.1298	3.85***
	Canar	0.0165	0.39
	Chimborazo	0.0243	0.61
	Cotopaxi	−0.1130	−2.00**
	Imbabura	−0.0111	−0.19
	Loja	−0.0946	−1.25
Constant		–	−0.74

Notes: * significant at 10%, ** significant at 5%, *** significant at 1% level. Observation are assumed independent across communities but not within communities; standard errors were adjusted accordingly.
† For dummy variables marginal effect is a discrete change from 0 to 1.
‡ Default province is Tunguragua.

	Predicted non-part.	*Predicted participant*
Actual non-participant	41	75
Actual participant	24	385
Per cent correct	63.1%	83.7%
Total per cent correct	81.1%	

participation, while the presence of non-black soils increases participation. The results indicate that land ownership and the type of lands operated have a significant impact on participation. Given the resource conservation message of PROMUSTA, this should not be surprising.

The strongest results come from the social capital variables. Organizational membership is shown to have increased the probability of participation by nearly 18 per cent while present or past directorship of an organization increased participation by the average farmer by 18 per cent. Being an indigenous household reduced participation by 9 per cent. These results indicate that a key difference between participants and non-participants is that participants were interested and receptive to organizations and were less likely to be indigenous. At the community level, distance to an urban center, a proxy for market access, increased participation suggesting those further away from the urban centers were more likely to participate. Population density also affected participation with a greater number of households per hectare reducing participation. Finally, the province of Azuay had lower participation and the province of Cotopaxi higher participation relative to the base province Tunguragua.

4. Inducing terrace adoption

In section 1, we noted that conservation programs in developing countries have a mixed history of success. Programs using incentives to induce conservation often resulted in abandonment when incentives were withdrawn. The CARE-PROMUSTA model offered a technological menu that included conservation measures and alterations to the agricultural system that enhanced short-term profitability rather than offering incentives to reduce short-term costs of conservation. In this section, we examine whether this package induced the adoption of conservation measures. Since only PROMUSTA participants were offered this menu of options, it is only their parcels that are evaluated. The results are therefore only relevant for PROMUSTA-type smallholders; specifically, those with characteristics noted in the previous section.

As noted in section 2, a number of conservation measures were promoted by PROMUSTA. However, terraces, both slow forming and bench terraces, were a key part of the program and we focus on the adoption of these measures. The question we want to answer is whether terraces are more likely to be adopted if complementary alterations in the agricultural production system occur; specifically, adoption of new crops, agroforestry, biological barriers, and improved agricultural production. The assumption is that, as with terraces, the adoption of these agricultural practices on a particular parcel would only occur if they were perceived to be profitable by the households. As an initial examination of whether terrace adoption is associated with altered agricultural practices, table 3 presents parcel level adoption of each technology for PROMUSTA participants. In total, 45.6 per cent of parcels operated by participant households had a terrace on them at the time of the survey. Among those who altered their agricultural system, 53.1 per cent had adopted terraces. To understand the adoption of these practices, we move to regression analysis.

Since PROMUSTA is offered as a package and the decision to adopt terraces and agricultural alterations is expected to be simultaneous, household decision making should be considered in a simultaneous decision making framework. Furthermore, both technologies are expected to be discrete decisions in that farmers choose to adopt the technology or

Table 3. *Adoption of terraces by PROMUSTA participants*

	Altered agricultural system	*Did not alter agricultural system*	*Total parcels*
Terrace adoption	147 53.1%	134 39.5%	281 45.6%
No terrace adoption	130 46.9%	205 60.5%	335 54.4%
Total parcels	277	339	616

not to adopt. The adoption decision can then be modeled as follows

$$t^* = \beta_0 + \beta_1' X_1 + \beta_2 a^* + \varepsilon_1, \quad t = 1 \text{ if } t^* > 0, \ 0 \text{ otherwise} \tag{1}$$

$$a^* = a_0 + a_1' X_2 + \varepsilon_2, \quad a = 1 \text{ if } a^* > 0, 0 \text{ otherwise} \tag{2}$$

$$E(\varepsilon_1) = E(\varepsilon_2) = 0, Var(\varepsilon_1) = Var(\varepsilon_2) = 1, Cov(\varepsilon_1, \varepsilon_2) = \rho$$

where

t^* = unobservable difference between benefits and costs of terracing,
t = observed adoption of terraces,
a^* = unobservable difference between benefits and costs of altering agriculture,
a = observed alteration of agricultural practices,
X_1 = set of exogenous factors influencing the terracing decision,
X_2 = set of exogenous factors influencing the decision to alter agriculture, and
$\varepsilon_1, \varepsilon_2$ = random disturbances associated respectively with terracing and agricultural alterations.

Note that equation (1) includes a^* as a dependent variable based on the hypothesis that alterations in the agricultural system induce terrace adoption. The expectation is then that β_2 will be positive and significant. Given the simultaneity of the equation system and the discrete nature of the dependent variables, a bivariate probit model is appropriate for estimating the equation system. Since the second dependent variable, a^*, enters into equation (1) as a dependent variable, the model is a recursive, simultaneous equations model. This particular type of model is presented in Maddala (1983, p. 123) and explained with an example from Burnett (1997) in Greene (2000, p. 852). Although equation (1) includes an endogenous variable on the right-hand side, namely a^*, no special attention needs to be given to this in formulating the log-likelihood function. The details of why this is the case can be found in Maddala and Greene. Greene notes that the reason simultaneity can be ignored in this model and not in the linear regression model is because in this case the log-likelihood is being maximized, while in the linear regression case certain sample moments are being manipulated that do not converge to the necessary population parameters in the presence of simultaneity. The standard bivariate probit therefore is appropriate for this model specification and is sufficient to address the endogeneity of a^*.

Results for the bivariate probit are presented in table 4. Since our primary interest is in terrace adoption, we begin with those results. The results

Table 4. *Bivariate probit on adoption (Number of parcels = 612)*

		Terrace adoption		*Altered agricultural system*	
		Coefficient	*z-stat*	*Coefficient*	*z-stat*
Complementary action	Altered agricultural system	1.1932	3.57***		
Parcel characteristics	Parcel area	0.0120	0.66	−0.0196	−0.75
	Slope (%)	0.0093	2.58**		
	Altitude (meters)	−0.0001	−0.26	0.0000	0.20
	Parcel distance to household (meters)			−0.0003	−4.05***
	Not black soil†	−0.2280	−1.93*	0.0606	0.75
	Rented land†	−0.2470	−1.20	0.3513	1.54
Human capital	Male labor/ha.	0.0119	2.45**	0.0012	0.28
	Female labor/ha.	−0.0116	−2.95***	−0.0008	−0.20
	Age of household head	0.0235	0.85	0.0128	0.54
	Age of household head squared	−0.0003	−0.96	−0.0001	−0.39
	Years in agriculture (head)			−0.0141	−2.88***
	Education level (household ave. years)	0.0362	1.26	−0.0001	0.00
Income source	Received income from off-farm work†	−0.0044	−0.03	0.2757	2.02**
Physical capital	Value of large animals owned (US$)	0.0000	−0.09	0.0000	−0.64
Community charactersitics	Years CARE in community	0.1286	4.22***	−0.0003	−0.02
	Distance to city (population >50,000)	−0.0037	−1.46	−0.0034	−1.80*
	Population density (households/ha)	0.2208	3.94***	−0.0281	−0.74
	Annual rainfall (cm/year)	0.0259	5.49***	0.0006	0.20
Provincial dummies‡	Azuay	−0.2097	−0.71	0.6875	4.70***
	Canar	−1.9848	−7.49***	0.8091	3.75***
	Chimborazo	−0.4153	−2.12**	0.5633	4.56***
	Cotopaxi	0.3656	1.14	0.5063	2.51**
	Imbabura	−1.0979	−4.27***	0.5439	3.55***
	Loja	−1.5840	−5.68***	0.6212	3.13***
Constant		−2.7638	−2.44**	−0.6067	−0.82

Table 4. *continued*

Notes: rho $= -0.4857$, Wald test of rho $= 0$ chi2(1) $= 2.67 \Longrightarrow$ Prob $>$ chi2 $= 0.10$
* significant at 10%, ** significant at 5%, *** significant at 1% level.
Observation are assumed independent across communities but not within communities; standard errors were adjusted accordingly.
† Dummy variables
‡ Default province is Tunguragua.

	Predicted non-adoption	*Predicted adoption*	*Predicted not altered*	*Predicted altered*
Actual non-altered/adoption	233	101	245	91
Actual altered/adoption	112	166	130	146
Per cent correct	67.5%	62.2%	65.3%	61.6%
Total per cent correct	65.2%		63.9%	

strongly indicate that alterations in the agricultural system had a significant and positive affect on the adoption of terraces. Thus, the hypothesis that complementary alterations in the agricultural system induce conservation appears to hold true. Not surprisingly, higher sloped land, where erosion is expected to be greatest was positively associated with terrace adoption. The presence of non-black soils was negatively associated with adoption. Since non-black soils are considered less fertile than black soils, the result indicates that conservation is more likely on parcels with fertile soil. Because of the high labor requirements of erecting terraces it was expected that labor availability, particularly of male labor would influence adoption. Farmers noted in informal conversations that terracing was 'work for men'. The results support this view with adoption positively associated with male labor availability and negatively with female labor availability.

At the community level, the time the community had been with CARE was positively associated with terrace adoption. This suggests that terrace adoption in a community increases with each year. This could be due to two reasons. One is that the labor requirements make households delay action until labor is available for putting in terraces. That is, households wait to invest in terraces until the off-season or another period when economic conditions lead to surplus household labor. Another reason is that some households delay adoption until they have better information on the benefits of adoption and adoption follows the familiar 'S-shaped' pattern with a few early adopters followed by 'followers' and then 'laggards' (Rogers, 1962). This process is partially encouraged by PROMUSTA in that they select farmer-promoters to initially undertake actions in the community facilitating the flow of information in the community; a process referred to in the literature as 'learning from others' (Foster and Rosenzweig, 1995). The results suggest that over time more terraces would have been adopted. While population density had a negative influence on participation in PROMUSTA, it had a positive effect on terrace adoption by participants. Greater population density suggests greater land scarcity, which may encourage careful land management. This result runs contrary to the view that higher population density will necessarily increase erosion. Higher rainfall, which can lead to erosion but is also associated with higher production possibility, was positively associated with terrace adoption. Finally, adoption of terraces appears to have varied across province with a number of provinces having a significantly lower probability of adoption than the base province Tunguragua. This result largely reflects the fact that soil degradation is a particular problem in Tunguragua and, because of this, a greater emphasis was placed on terraces in this province as a mechanism to improve soil fertility and water retention.

The effects noted thus far are the direct effects of household characteristics on terrace adoption. Since altering agricultural production is shown to influence the adoption of terraces, household characteristics also have an indirect effect on terrace adoption through their influence on alteration of agricultural practices. The results from the estimation of equation (2) suggest that the distance of the parcel from the household influences agricultural practices. Many of the practices promoted by PROMUSTA required additional effort, investment, and monitoring by households.

The costs of these activities are likely to increase with the distance from the household. Somewhat surprisingly, experience in agriculture was negatively associated with adopting new agricultural practices (controlling for age). This suggests that individuals that are newer to farming may be more willing to take risks and explore alternative farming systems while those with more experience may be fairly set in their practices. Also somewhat surprising is the positive relationship between off-farm income and alteration of agricultural practices. This could be indicative of a complementary between off-farm income and altering the agricultural system. Off-farm income may be used as a source of finance for investing in agriculture or may be a mechanism to manage risk in the event the new practices fail. Access to off-farm income then allows for the investment in new practices. Alternatively, it may be the case that those who seek off-farm work are also the type of person that would want to try to diversify agriculture. A final possibility is that off-farm work is usually available near urban centers and suggests market access. This final hypothesis also comes through in the distance to urban center variable. The negative association between distance to urban center and changing the agricultural system suggests that more remote households may not be willing or able to alter practices and, in particular, move to new crops because they have limited market access. This indirect effect of market access on terrace adoption has important policy implications for conservation programs. To induce conservation may require making the agricultural system more profitable in the short-term. However, developing profitable ventures requires good market access. This type of conservation program may therefore work better in areas near urban centers. Finally, all regions were found to have different adoption rates than the province of Tunguragua. Provinces roughly correspond to the administrative units of the PROMUSTA program. Differences could be due to differences in emphasis across provinces or uncontrolled differences in agro-ecological or socio-economic factors. One reason for this result, as noted in the discussion of terrace adoption, is that Tunguragua has particular problems with soil quality which make it more likely to adopt terraces but less likely to alter agricultural practices because of the lower agricultural potential.

5. Household's intensity of adoption

The results thus far show that the adoption of conservation measures was positively associated with alterations of the agricultural system. The next step to consider is whether this methodology used by PROMUSTA was successful in promoting conservation in the communities in which they worked. To examine this question, we used the data collected on the intensity of adoption of resource conservation measures. Recall from section 2 that data on the percentage of land area 'properly managed' (based on CARE criteria) was calculated for each farmer, including both participants and non-participants. A farmer who managed none of the land in a manner deemed acceptable would have an adoption level of 0 per cent; while a fully adopting farmer would have an adoption level of 100 per cent with most farmers somewhere in between. The data are thus censored at 0 per cent and

Table 5. *Intensity of adoption*

Level of adoption	*Total*	*Participants*	*Non-participants*
0%	25.7%	10.3%	80.2%
1–10%	6.7%	7.3%	4.3%
11–20%	9.3%	10.5%	5.2%
21–30%	7.8%	9.1%	3.5%
31–40%	5.7%	7.1%	0.9%
41–50%	7.8%	10.0%	0.0%
51–60%	7.4%	8.8%	2.6%
61–70%	7.1%	8.8%	0.9%
71–80%	7.2%	8.8%	1.7%
81–90%	4.0%	4.9%	0.9%
91–100%	11.2%	14.4%	0.0%

100 per cent. Table 5 presents a breakdown of the intensity of adoption for the sample as a whole and by participation. Of the 525 households included in the analysis, 26 per cent did not adopt any new practices and thus had an intensity of adoption of 0 per cent. Eleven per cent adopted the appropriate technologies on all or nearly all their land and the remaining 64 per cent were somewhere in between (with a nearly uniform distribution). Of those with an intermediate level of adoption, the average percentage of adoption was 46 per cent. Only 10 per cent of participant household had not adopted any conservation practices compared with 80 per cent of non-participant households, suggesting a strong program effect.

While the program appears to have had a significant effect on the resource management of PROMUSTA participants, there remains significant variability in the intensity of adoption. One possible explanation is that farmers are still in the process of adopting the package and it is simply a matter of time before full adoption occurs. Alternatively, other factors may limit or enhance adoption. To carefully analyze the effect of PROMUSTA on adoption and to understand the variability of adoption rates we again employ regression analysis. In particular, we are interested in examining the following relationship

$$i = \phi_0 + \phi_1' X_3 + \phi_2' p + \varepsilon_3,\ 0 \le i \le 100 \tag{3}$$

$$E(\varepsilon_3) = 0, Var(\varepsilon_3) = 1$$

where
i = intensity of adoption,
X_3 = set of exogenous factors influencing the intensity of adoption,
p = 1 if PROMUSTA participant, 0 otherwise, and
ε_3 = random disturbances associated with the intensity of adoption.

Since the dependent variable, i, is censored on both sides of the distribution (0 per cent and 100 per cent), a double-censored regression model is appropriate. However, there is an additional problem of the endogeneity of PROMUSTA. As specified, PROMUSTA enters the equation as a dummy variable that presumably measures the influence of participation on the intensity of adoption. The problem with this specification is that, as noted in section 3, it may be the case that PROMUSTA participants would have adopted some conservation measures even if PROMUSTA had not intervened. The coefficient on the dummy variable may not measure the effects of PROMUSTA, but reflect the characteristics of the types of households that are likely to join PROMUSTA.

The Hausman test of endogeneity rejects the hypotheses that PROMUSTA is exogenous and thus the coefficient in the double-censored regression model would be biased (see Hausman, 1978, 1983). To deal with the endogeneity of PROMUSTA, an instrumental variable approach is used in which the predicted value of PROMUSTA participation is included in the intensity of adoption equation (with standard errors adjusted as appropriate). This is a common approach in the evaluation literature with this type of cross-sectional data to evaluate the effects of program participation on an outcome when participation is endogenous (see Ravallion, 1999). A key to this approach is to find appropriate instruments that are correlated with participation but not with the error term in the intensity of adoption equation. We use the social capital variables as instruments arguing that these influence participation, but not the adoption of natural resource management practices.

There are two potential complications with this approach. The first is the fact that participation in PROMUSTA is a discrete variable. To deal with this, we specify participation as in table 2 but use a linear probability model rather than a probit.[7] Results from the linear probability model are the same as for the probit (table 2) with the exception of the loss of significance for owned land and distance to urban center. The second issue is the double censoring of the dependent variable in equation (3), which complicates the instrumental variable regression. For this, we use Amemiya Generalized Least Squares (AGLS) estimators as specified by Newey (1987) which allows the estimation of censored regressions with endogenous variable.[8] This allows us to instrument participation in PROMUSTA while maintaining the double-censored nature of the regression.

In table 6, the results for the double-censored model using the actual value of participation and for the double-censored model using the instrumental variable approach are reported. As can be seen, the results are fairly robust, although the model without instruments appears to underestimate the effect of PROMUSTA. The results clearly indicate the strong effect of PROMUSTA on the intensity of adoption especially when controlling for endogeneity. Without PROMUSTA the intensity of adoption of conservation measures would have been substantially lower.

The results also indicate that the amount of male labor per hectare positively and significantly affected the intensity of adoption, while female labor negatively impacted the intensity of adoption, although this is not significant for the instrumental variable regression. This suggests that

[7] Angrist (2000) suggests this approach for limited dependent variable models and argues that it is consistent and that this approach is safer since predicting using a probit is only consistent if the model is exactly correct.

[8] The estimation is done using STATA based on a program written by Harkin (2001) that uses the formulae developed by Newey (1987).

Table 6. *Regressions on intensity of adoption (Number of households = 525)*

		Double-censored regression		*Double-censored instrumental variable regression*	
		Coefficient	*z-stat*	*Coefficient*	*z-stat*
Participation in CARE PROMUSTA		84.675	14.39***	104.414	8.61***
Human capital	Male labor/ha.	0.330	1.94*	0.314	1.84*
	Female labor/ha.	−0.292	−1.86*	−0.322	−2.04**
	Age of household head	−0.041	−0.05	−0.577	−0.69
	Age of household head squared	−0.002	−0.31	0.002	0.26
	Years in agriculture (head)	0.013	0.07	0.129	0.65
	Education level (household ave. years)	2.384	2.32**	2.324	2.27**
Income source	Received income from off-farm work†	−2.901	−0.73	−1.629	−0.40
Natural capital	Land owned (hectares)	−0.758	−1.17	−0.721	−1.11
	Number of parcels	−6.602	−2.45**	−8.339	−2.94***
	Slope of steepest parcel (%)	0.075	0.71	0.041	0.39
	Altitude of highest parcel (meters)	0.008	0.93	0.009	1.04
	Distance to furthest parcel (meters)	0.005	3.30***	0.005	3.70***
	Fraction of land with non-black soil	−0.910	−0.22	−2.328	−0.57
Physical capital	Value of large animals owned (US$)	0.001	0.58	0.000	0.38
Community charactersitics	Years CARE in community	3.334	4.28***	3.243	4.17***
	Distance to city (population >50,000)	−0.204	−2.47**	−0.207	−2.52**
	Population density (households/ha)	2.993	1.30	3.580	1.54
	Annual rainfall (cm/year)	0.196	1.24	0.188	1.19
Provincial dummies†	Azuay	−14.851	−1.82*	−16.119	−1.98**
	Canar	−28.061	−3.37***	−28.520	−3.43***
	Chimborazo	8.284	1.22	7.231	1.07
	Cotopaxi	−9.550	−1.22	−11.325	−1.44
	Imbabura	−7.089	−0.76	−6.709	−0.72
	Loja	−19.240	−1.92*	−17.234	−1.71*
Constant		−66.460	−2.00**	−69.524	−2.09**

Notes: * significant at 10%, ** significant at 5%, *** significant at 1% level.
† Default province is Tunguragua.

households require male labor to invest in resource conservation and households endowed with large amounts of female labor are less likely to invest, or will invest more slowly, in conservation. Education was positively and significantly related to adoption intensity. This corresponds to the adoption literature which notes that households with more educated members are likely to be more receptive to new information (Feder *et al.*, 1985). Taken together, these results indicate that both labor constraints for male labor and information availability are important in determining the intensity of adoption.

Physical assets, as measured by total land owned and value of animals owned, were not found to significantly affect adoption. However, the number of parcels owned by the farmer negatively impacted the intensity of adoption suggesting certain fixed costs associated with investment in resource conservation. Neither the slope of the steepest plot a farmer operated nor the altitude of the highest plot a farmer operated was found to significantly influence adoption. Surprisingly, the distance to the furthest parcel positively influenced the intensity of adoption. The number of years in which CARE worked with the community positively affected the intensity of adoption. This means that over time households were managing more land in a manner consistent with the PROMUSTA program and the expectation is that resource conservation would have continued improving after the survey was conducted. The distance to an urban center measures access to markets and, likewise, land values. The closer the household was to an urban center, the higher the intensity of adoption. This is most likely because access to markets allows a higher return to alterations in agricultural production. Correspondingly, it could be that land markets function better near cities and therefore farmers are more able to capture returns to investments in conservation. Population density and rainfall were not found to influence the intensity of adoption. Regional dummies show that there were significant differences in adoption across some regions. In particular, Azuay, Cañar, and Loja were found to have significantly lower intensities of adoption than Tunguragua, which can partially be attributed to the strong emphasis on terrace adoption and natural resource management in Tunguragua.

6. Impact assessment

Although the beneficiaries of PROMUSTA include non-participating farmers and off-farm beneficiaries of improved resource management, direct benefits accrue to participating farmers and we focus on these farmers in assessing the impact of PROMUSTA. PROMUSTA worked with nearly 10,000 families in 193 communities. The benefits to these farmers are an increased value of current production and a higher value of future production due to the sustainable management of resources. Determining a numerical value for the benefits is difficult and not possible with the available data. Instead we examine the actions households have taken and farmers' perceptions of the value of the project as noted in the household survey (table 7). Of the 9,333 households participating in the PROMUSTA program 413 were surveyed. Nine out of ten of these households adopted some part of the PROMUSTA technological package, suggesting that at

Table 7. *Impact of PROMUSTA*

Economic value	*Sampled participant households*	*Per cent sampled households*	*Total participant households*
Number of households	413	100.0%	9333
Adoption of some practices	371	89.8%	8384
Improved income	312	75.5%	7051
Soil quality improvement	248	60.0%	5604
Activities worth the effort	353	85.5%	7977
Resource management (land)	*Sampled land area**	*Per cent sampled land area*	*Total land area**
Area (hectares)	480	100.0%	10,847
Appropriately managed	174	36.3%	3932
With terraces	183	38.1%	4135
With control of water erosion	187	39.0%	4226
With improved water management	36	7.5%	814

Note: * Participant operated land.

the time of the survey a total of 8,384 Ecuadorian farmers in some way altered their agricultural system as a direct result of the program. Assuming adoption only occurred when there was an anticipated benefit, this suggests more than 8,000 households benefited from the PROMUSTA program. Three-quarters of surveyed households reported improved income as a result of program participation implying more than 7,000 households realized short-term improvements in income. Sixty per cent of farmers noted soil improvements indicating they perceived long-term benefits of adoption. Eighty-five per cent of participating households – 95 per cent of those that adopted some practices – noted that the activities undertaken were worth the effort. Therefore, nearly 8,000 of the 9,333 households participating in the PROMUSTA program found the program valuable.

The 413 participant households that were surveyed operated 480 hectares of land. Assuming a similar level of land operation, participating households operated in total 10,852 hectares of land. Using CARE's criteria, 42.1 per cent of land operated by participants was managed better (at the time of the 1996 survey). This suggests that 4,572 hectares of land were being managed in a sustainable manner. Additionally, 4,808 hectares had terraces, 5,019 hectares had measures that help control water erosion, and 946 hectares had improved water management (reservoirs and irrigation systems).

The benefits discussed here should be considered conservative estimates for two reasons. First, only benefits to participating households are discussed. Presumably, non-participating households might have adopted a number of the practices promoted by PROMUSTA and received benefits as well. Additionally, improved resource management should reduce erosion and limit the off-farm negative externalities. Second, as noted in both the probit on terracing (table 4) and the intensity of adoption regression (table 6), adoption of conservation technologies takes time. As the households continue to adopt these practices, more land will become managed in a sustainable manner. These benefits are yet to be felt, but the results indicate they are likely to come.

7. Conclusions and implications for conservation programs

The results of this analysis suggest that CARE through its PROMUSTA program was successful in promoting resource conservation in the communities of the Ecuadorian Andes where the program operated. PROMUSTA opportunistically selected from among a large set of available conservation and agricultural technologies and selectively offered them in perceived high payoff situations as a pathway for scaling up the application of new technologies. The program led to a higher intensity of adoption of conservation measures than would have occurred if the program had not operated. Furthermore, the results indicate that adoption levels were likely to have increased after the survey was conducted. While it may not be possible to replicate this level of success in all communities in the Ecuadorian Andes, the approach is likely to be successful in communities with characteristics similar to PROMUSTA communities; namely, in communities with high levels of social capital and low levels of migration.

A key to CARE's success was the promotion of conservation measures in conjunction with measures that enhanced the short-term profitability of agriculture. In particular, the adoption of terraces was found to increase significantly when accompanied by alterations to the agricultural system such as new crops, biological barriers, and improved agricultural production. The implication of these results for program design is clear. An alternative to providing subsidies or other forms of assistance to farmers to induce conservation is to promote alterations in the agricultural system that enhance the short-term profitability of agriculture. This is likely to lead to higher levels of adoption and to be more sustainable in that farmers are more likely to maintain such changes. One difficulty in doing this is that it requires identifying changes in the agricultural system that will complement conservation and improve short-term profitability. CARE's approach was to offer a diverse menu of innovations from which the household could choose. This allowed farmers to choose a set of options that fit their particular needs and circumstances. While this appears to be generally successful, certain households seemed in a better position to take advantage of this system. Households that were closer to urban centers were more likely to alter agricultural practices probably because of their greater market access. Farmers with black soils and thus higher agricultural potential were also more likely to adopt. These results suggest this type of program may be more successful in areas near urban centers and with fertile soils. Furthermore, developing this type of program requires a well-organized extension system and knowledgeable extension agents that have adequate information on agricultural potential for an area, as well as household characteristics and constraints. The PROMUSTA project internalized this last caveat by providing its own extension agents and continuously trained them in the diverse technologies they were offering.

One area of potential concern in terms of gender equality are the results for both plot-level terrace adoption and household-level intensity of adoption on male and female labor availability. The results indicate that male labor availability increases adoption while female labor availability decreases adoption. If this is the case and adoption improves short-term profitability and long-term sustainability, this could lead to greater gender inequality in participating communities. Since the low adoption rate seems to be linked to terrace adoption and the need for male labor for this activity, it may be appropriate to provide some assistance, in terms of male labor services, to households endowed primarily with female labor.

This analysis offers some clear lessons for those designing resource conservation projects both in Latin America and elsewhere. First, the selection of communities and the self-selection of participants appear to matter. Although the data was insufficient to draw clear conclusions, the level of social capital in participant communities and among participants seems important. Second, resource conservation should not be done in isolation and should be part of a broader attempt to transform the agricultural system. Farmers are more likely to adopt conservation measures as part of a transformation that makes agriculture more profitable. Doing this can be difficult since it requires identifying profitable agricultural activities that complement resource conservation. It is easier to find such activities if farmers have access to relatively fertile land and have reasonable access to markets. This suggests that programs should be targeted to areas with this type of potential. Third, programs are more likely to be successful if they offer a variety of options for managing resources and transforming agriculture, are well-organized and work closely with farmers in designing a plan to alter farm management. These were all key components of the PROMUSTA program and appear essential to the success of the program.

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